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PHARYNGOESOPHAGEAL RECONSTRUCTION WITH THE USE OF VASCULAR ANASTOMOSES: OPERATIVE MODIFICATIONS AND LONG-TERM PROGNOSIS

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Objective: **Vascular surgical techniques have contributed to the success of pharyngoesophageal reconstruction. We report our methods and analysis of postoperative complications, quality of life, and long-term prognosis.** ***Methods:*** **Sixty-seven patients who underwent pharyngoesophageal reconstruction with use of vascular anastomoses comprised the study population. The operative procedures performed were free jejunal autograft transplantation in 54 patients, gastric pedicle placement with vascular anastomoses in 2, jejunal pedicle with vascular anastomoses in 4, colonic pedicle with vascular anastomoses in 4, free jejunal graft and gastric pedicle in 2, and free jejunal graft and jejunal pedicle in 1. The common carotid artery and internal jugular vein were primarily used as the recipient vessels. The period of postoperative observation ranged from 3 days to 145 months.** ***Results:*** **The postoperative complications noted were dehiscence in 7 patients, graft failure in 1, wound infection in 2, small bowel intussusception in 4, pneumonia in 2, disseminated intravascular coagulation in 1, and pancytopenia in 1. Revascularization was successful in all but 1 patient, and oral intake was achieved in 58. Persistent swallowing dysfunction was recognized in 4%. Speech restoration was achieved in 57% of the patients with esophageal speech in 7% and with an artificial larynx in 50%. In the long-term follow-up, 36% of our patients died of the primary disease, 9% died of other diseases, and 55% are alive.** ***Conclusions:*** **Esophageal reconstruction with the use of vascular anastomoses affords low morbidity and mortality. Postoperative swallowing and speech are satisfactory, and the function of the reconstructed esophagus is well preserved for as long as 10 years. (J Thorac Cardiovasc Surg 1997;113:975-81)**

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In pharyngoesophageal reconstruction operations vascular anastomoses are used to transplant a free intestinal graft or to restore blood flow in the oral portion of a pedicled intestine.[1] We have performed free jejunal grafting in reconstruction of the hypopharynx and cervical esophagus,[2] and when a pedicled intestine could not be lifted up to the desired level in reconstruction of the esophagus we have supplemented the tract with insertion of a free jejunal graft. To reduce ischemic complications at the oral end of a pedicled intestine, we have added a vascular anastomosis for restoration of blood flow in the tract.

Applications of the technique of vascular anastomoses in general surgery were presented in a lecture by Carrel[3] in 1906 in which experiments involving intestinal autografting were described. In 1946 Longmire[4] used pedicled jejunum for esophageal reconstruction and reestablished blood flow at the oral end by vascular anastomoses. In 1959 Seidenberg and colleagues[5] reported the successful reconstruction of the cervical esophagus by a revascularized isolated jejunal segment. In 1962 Nakayama and associates[6] reported a vascular anastomosing apparatus with which a free sigmoid graft and the oral end of a pedicled gastric tube were revascularized, and in 1965 Jurkiewicz[7] confirmed the clinical usefulness of the procedures. These surgical methods, however, were not commonly used at the times these articles appeared, because the anastomotic techniques for small blood vessels were not yet fully established.

We have consecutively performed free jejunal autograft transplantation and other esophageal reconstructions with vascular anastomoses in 67 cases since December 1983. We review the cases herein and discuss the indications, operative techniques, postoperative complications, and prognosis of our procedures. We also discuss the long-term results in our patients with pharyngolaryngoesophagectomy.

Patients and methods

The 67 patients in our series included 47 with hypopharyngeal or cervical esophageal cancer, 9 with thoracic esophageal cancer, 2 with double cancer of the hypopharynx and thoracic esophagus, 5 with thyroid cancer, and 4 with laryngeal fistula or esophageal stricture after an operation for laryngeal cancer. The ages of the patients ranged from 38 to 88 years, with a mean of 64.0 years. There were 46 male and 21 female patients. The extent of the cancer and the vascular nature were evaluated by computed tomography before the operation.

The operative procedures performed were free jejunal autograft transplantation in 54 patients, gastric pedicle placement with vascular anastomoses in 2, jejunal pedicle with vascular anastomoses in 4, colonic pedicle with vascular anastomoses in 4, free jejunal graft and gastric pedicle in 2 (Fig. 1), and free jejunal graft and jejunal pedicle in 1. The feeding artery in the vascular anastomoses was the common carotid artery in 56 patients, transverse cervical artery in 4, facial artery in 1, lingual artery in 1, superior thyroid artery in 1, inferior thyroid artery in 1, ascending cervical artery in 1, internal thoracic artery in 1, and brachiocephalic artery in 1. The recipient vein in the vascular anastomoses was the internal jugular vein in 63 patients, external jugular vein in 2, and common facial vein in 1. One patient with pedicled tract reconstruction received arterial anastomosis only.

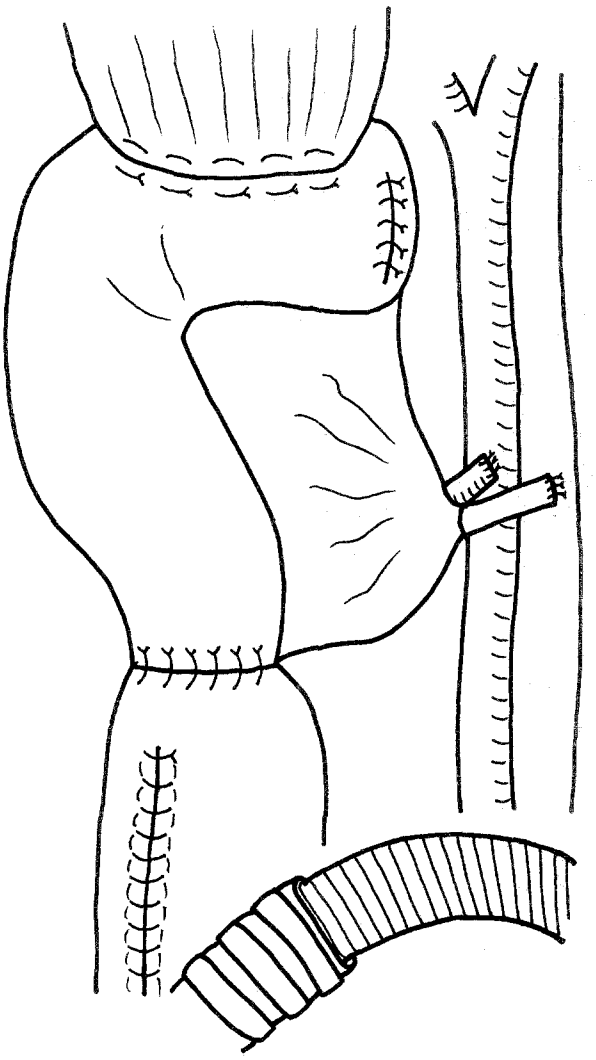

Fig. 1. Composite reconstruction with free jejunal graft and pedicled gastric tube.

In free jejunal grafting, vascular anastomoses were applied before intestinal anastomoses (Fig. 2). Heparin (1 mg/kg) was administered intravenously, and the internal jugular vein was clamped. With the aid of 2.25-fold

Fig. 2. The jejunal vein is anastomosed in end-to-side fashion to the internal jugular vein *(left)* and the jejunal artery likewise to the common carotid artery *(right)*.

magnification loupes, the jejunal vein was anastomosed in an end-to-side fashion. The wall of the internal jugular vein was incised, and interrupted 7-0 polypropylene sutures were placed in the anterior wall. The jejunal graft was turned outward, and the posterior part of the anastomosis completed with a running suture. After the common carotid artery was side-clamped or crossclamped, a 3 to 4 mm diameter opening was prepared with a vascular punch. The jejunal artery and the carotid artery were anastomosed in the same manner as the veins. After the clamps of the veins and arteries were released, the jejunal graft became pink and started to exhibit peristalsis. A Doppler flowmeter was used to confirm blood flow in the graft. The time required for vascular anastomoses was less than 1 hour.

The period of postoperative observation ranged from 3 days to 145 months, with a mean of 27.2 months. The postoperative viability and function of the reconstructed esophageal tract were evaluated with barium study of the gastrointestinal tract and color Doppler ultrasonography (Fig. 3). When symptoms such as dysphagia or bloody spittle were noticed, fiberscopic examination or angiography was performed (Fig. 4). The length of survival was determined from the day of operation, and the actuarial survival rates in patients with hypopharyngeal or esophageal cancer ($n = 58$) and in patients with thyroid cancer or other diseases ($n = 9$) were calculated by the Kaplan-Meier method.

Results

The postoperative complications noted were dehiscence in 7 patients, graft failure in 1, wound infection in 2, small bowel intussusception in 4, pneumonia in 2, disseminated intravascular coagulation in 1, and pancytopenia in 1. No neurologic deficits were observed after clamping of the carotid artery. The patient with disseminated intravascular coagulation and the patient with pancytopenia died at 3 and 10 postoperative days, respectively, and these were the only two patients who died within 30 days after the operation. Three of the 7 patients with dehiscence recovered with treatment by drainage and total parenteral nutrition, and 2 required reoperation (radial forearm free flap in one and jejunostomy in the other). One patient with dehiscence died of cardiac failure 3 months after operation, and another died of arterial bleeding in the neck wound 6 months after the operation. The graft failure occurred in a patient who had cervical esophageal cancer with lymph node metastasis and the venous anastomosis had been performed with the external jugular vein because the internal jugular vein showed cancer invasion. The transplanted graft became edematous and cyanotic, and the patient died of venous bleeding 2 months after operation. None of the wound infections was serious, and they healed without any other complications. The 4 patients in whom intussusception developed underwent reoperation, and 3 of them required bowel resection.

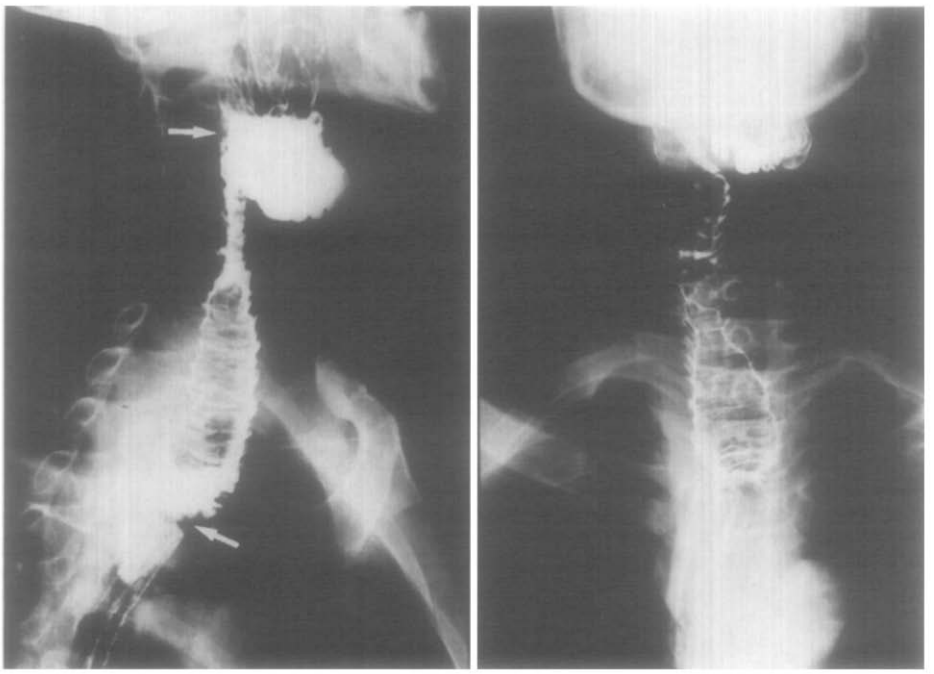

Fig. 3. Postoperative anteroposterior *(right)* and right oblique *(left)* gastrointestinal tract barium roentgenograms. *Arrows* indicate pharyngojejunal and jejunogastric anastomoses.

The 2 patients with pneumonia died 1 and 2 months after operation, respectively. Consequently, there were 7 hospital deaths (10.4%) in the 67 patients. Revascularization was successful in 66 (98.5%) patients, and oral intake was achieved in 58 (86.6%).

Of 58 patients in whom the swallowing function was assessed, 7 had persistent or late-onset dysphagia. In 4 patients with dysphagia stenosis of the suture line of the jejunal graft was confirmed and the patients underwent balloon dilation or cutting with fiberscopic electrocautery at 2 to 17 months after the operation. These patients regained satisfactory swallowing function. One of 3 patients with nonstenotic dysphagia required temporary insertion of elemental diet tubing at 13 months after the operation.

Of 54 patients in whom vocal function was assessed after laryngeal resection, 23 could barely speak. Four patients gained esophageal speech, and 27 could speak with an artificial larynx (pipe or electronic type).

Long-term follow-up showed that 24 patients died of the cancer and 6 died of other diseases. Thirty patients were alive at the close of this study (April 1996). The actuarial survival rates were 65.0% at 12 months and 32.2% at 60 months after the operation in the patients with hypopharyngeal or esophageal cancer and 77.8% at 60 months after the operation in the patients with thyroid cancer or other diseases (Fig. 5).

Discussion

Indications for vascular anastomosis in esophageal operations. In reconstruction after hypopharyngeal or cervical esophageal resection, free intestinal grafting is superior to other procedures such as skin flap or pedicled intestine placement.[8] Interposition of a free graft is also needed in esophageal reconstruction when a long pedicle cannot be obtained because of a short gastric tube or previous intestinal resection. In esophageal operations one of the most frequent causes of death in addition to pulmonary complications is dehiscence.[9] Inoue and colleagues[1] reported that vascular anastomosis in the oral end of a pedicle resolves these complications.

Techniques in vascular anastomoses. Recent advances in vascular surgery have made free intestinal grafting the most commonly used method in the reconstruction of the cervical esophagus. The techniques of vascular anastomosis are modifications of those used in coronary bypass operations or microvascular operations, and the techniques are well established.[10] The crucial decision in each operation

is determination of the appropriate vessels to be used in the recipient. We use primarily the internal jugular vein and common carotid artery for anastomosis. The jugular vein is usually crossclamped during the anastomosis; however, if one of the bilateral veins is resected because of cancer invasion, we use a side clamp for partial occlusion during the venous anastomosis. The carotid artery is usually also partially occluded while side-clamped during the anastomosis, but if the distal arterial pulsations are good after temporary occlusion of the carotid artery, we place a crossclamp during the arterial anastomosis. The advantages of using these vessels are that cervical lymph node excision can be performed without concern for preserving recipient vessels, a large opening for the anastomosis can be prepared to obtain sufficient blood flow, suturing is easy, and the incidence of kinking of vessels is low. On the other hand, the disadvantages include possible disturbance in cerebral circulation during the clamping of the vessels and more serious complications should vascular rupture occur. If advanced sclerotic changes are found during the preoperative evaluation or at the time of exploration, the branches of the external carotid or subclavian artery alternatively can be used.

Postoperative complications. The major complications in esophageal reconstruction with vascular anastomoses were graft failure and bowel intussusception.[11] Because we perform the vascular anastomoses before the intestinal anastomoses, we can revise the vascular anastomosis in the event of graft ischemia or congestion. After the operation we do not administer any antithrombotic drugs (heparin is used at the time of clamping of the vessels). The cause of venous congestion in one free jejunal graft was thought to be late-onset thrombosis.

Flynn and coworkers[12] reported intussusception as a complication after harvest of a free jejunal graft. The incidence of intussusception was 8% in our series. We harvested a free jejunal graft from the area supplied by the second or third jejunal arteries, near the ligament of Treitz. The fixation of one side of the jejunum adjacent to the anastomotic site may have increased the incidence of abnormal bowel motility resulting in intussusception. To avoid this complication, the free jejunal graft should be harvested at a site removed from the Treitz ligament, the mesenterium should be closed correctly, and a large anastomotic orifice should be made.

The incidence of dehiscence of 10% in our patients is lower than that cited in other reports: a 19% incidence of fistula formation was reported by Reece and colleagues[13] and a 29% incidence by Hoorweg and colleagues.[14] Because dehiscence is caused by many factors including malnutrition, ischemia at the anastomotic site, perioperative cardiopulmonary dysfunction, and infection, an effort should be made to eliminate each potential cause.

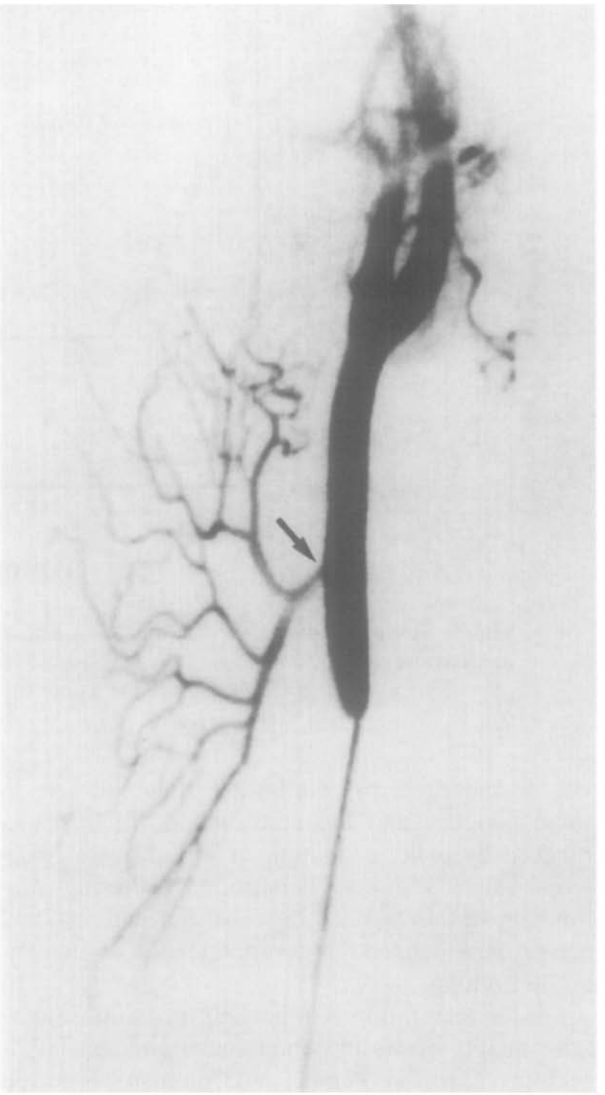

Fig. 4. Angiogram of free jejunal graft. *Arrow* indicates the anastomosis of the jejunal artery and common carotid artery.

Swallowing function and ability to talk. Early postoperative dysphagia occurs within a few months. The causative factors are considered to be loss of the superior pharyngeal constrictor, extensive proximal resection, redundant bowel, hyperperistalsis, edema, and anastomotic stricture.[1, 15] The dysphagia

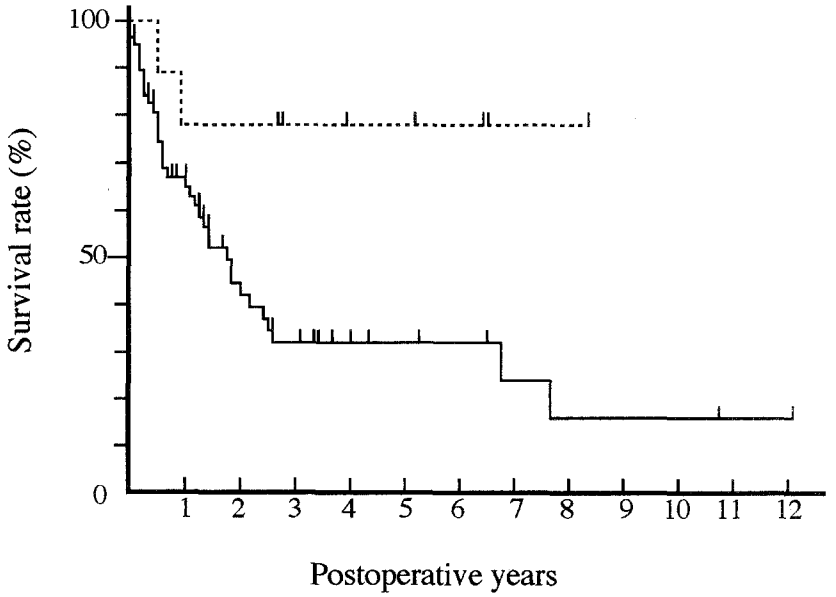

Fig. 5. Survival curves for patients who underwent esophageal reconstruction with use of vascular anastomoses. The *solid line* is the survival curve for the patients with hypopharyngeal or esophageal cancer ($N = 58$). The *dotted line* is the survival curve for the patients with thyroid cancer or other diseases ($N = 9$).

was surmounted by swallowing rehabilitation in some patients, and the anastomotic stricture was relieved by balloon dilation or cutting with fiberscopic electrocautery. Persistent swallowing dysfunction was recognized in 4% of our patients, and one of these needed temporary insertion of elemental diet tubing.

Speech restoration is important for the postoperative quality of life in patients who undergo laryngectomy. Mansour, Picone, and Coleman[16] reported that 70% of patients with pharyngolaryngoesophagectomy were able to communicate by esophageal speech or with the aid of an electronic device. In our group, 57% of the patients could speak with esophageal speech (7%) or with artificial laryngeal speech (50%). One of the reasons for the low rate of preserved speech compared with that obtained by Mansour, Picone, and Coleman[16] may be the use of the pipe type of artificial larynx, which is more difficult to use than the electronic type. Social and psychologic factors associated with aging may also have contributed to the discrepancy. Singer[17] and Yoshida[18] and their colleagues performed primary voice restoration and achieved success in 85% of their cases. Kawahara and associates[19] reported free terminal ileum and cecum transplantation with tracheo-ileal puncture, and the voice was restored in 80% of their patients with pharyngolaryngoesophagectomy. Most of our patients are satisfied with the ability to talk with the artificial larynx, and for that reason we recommend primary voice restoration as the second choice.

Outcome. In our long-term follow-up, 36% of our patients died of the primary disease, 9% died of other diseases, and 55% are alive. Recurrence of the cancer continues to limit the survival of patients.[20] The reconstructed esophageal conduits were vital through the follow-up period in all patients except the one with early graft failure. Because the patency of the revascularized vessels was not evaluated in all patients, the esophageal conduits might be perfused by collateral circulation with neoangiogenesis.[21] The important point is that the esophageal conduits function during the entire postoperative life span of the patient. The longest survivor, who received free jejunal transplantation because of cervical esophageal cancer 12 years ago, is able to eat satisfactorily and speaks well with the artificial larynx.

Esophageal reconstruction with the use of vascular anastomoses made it possible to treat patients for whom an operation would otherwise not have been an option. The operative morbidity and mortality were decreased, particularly in operations on the hypopharynx and cervical esophagus. The postoperative quality of life in our patients

was satisfactory, and the function of the reconstructed esophagus was well preserved for up to 10 years.

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